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How to be a Roboticist

Brian O’Neil

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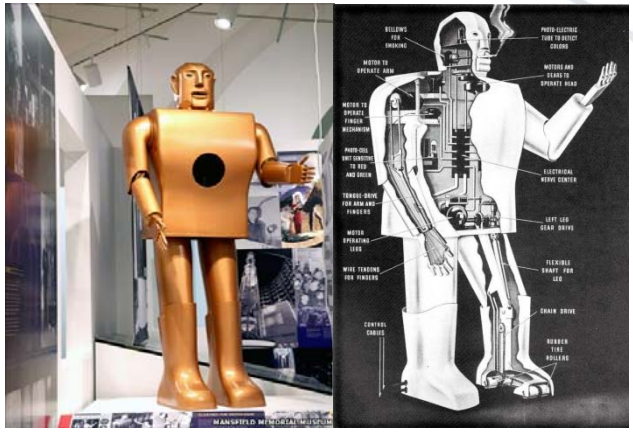
How I became a roboticist

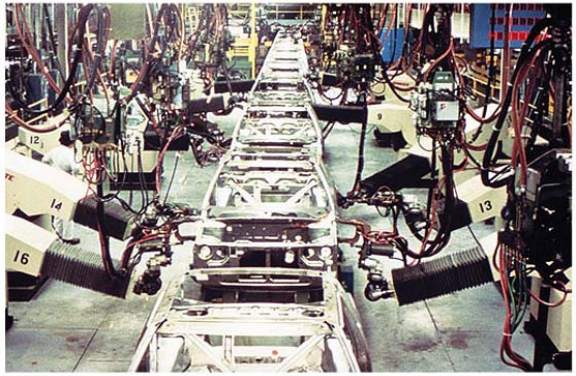
- Always wanted a robot…
- Studied hard – took the hard classes
- Mechanical Engineering
- Research projects
- Graduate School – Nuclear engineering and robotics

What is a robot?

Karakuri Automaton, Japan ca. 1800

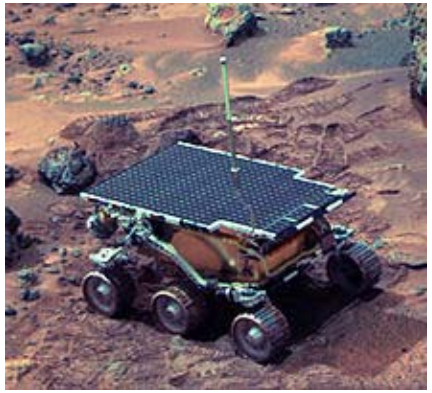


Electro, Westinghouse, 1939



Unimate, 1961

Deep Blue, IBM, 1997



Sojourner, NASA, 1997

Aibo, Sony, 1999

Roomba, iRobot, 2002

What is a robot?

- Questions:
  - What does a robot look like?
  - What does a robot do?
  - Can you think of anything all robots have in common?
- My definition:
  - Robot: A programmable machine that can do work in the physical world

Modern Robotics

Self-driving car, Google, 2012

Baxter, Rethink Robotics, 2012

Atlas, Boston Dynamics, 2013

UBR-1, Unbounded, 2014

Quadrotor swarm, UPenn, 2012

Discussion

- Questions:
  - What do robots do for humans today?
  - What don't they do, that we thought they would? Why not?
  - What will they do in the future?
- Thoughts:
  - Autonomy vs. teleoperation
  - How hard is the task? The environment?

How are robots programmed?

Teach Pendant

Motoman Teach Pendant

- Teach/Play method
- “Remote Control” the task, then play it back
- Very *robust* method of programming
- Flexible to program, but not at playback

How are robots programmed?

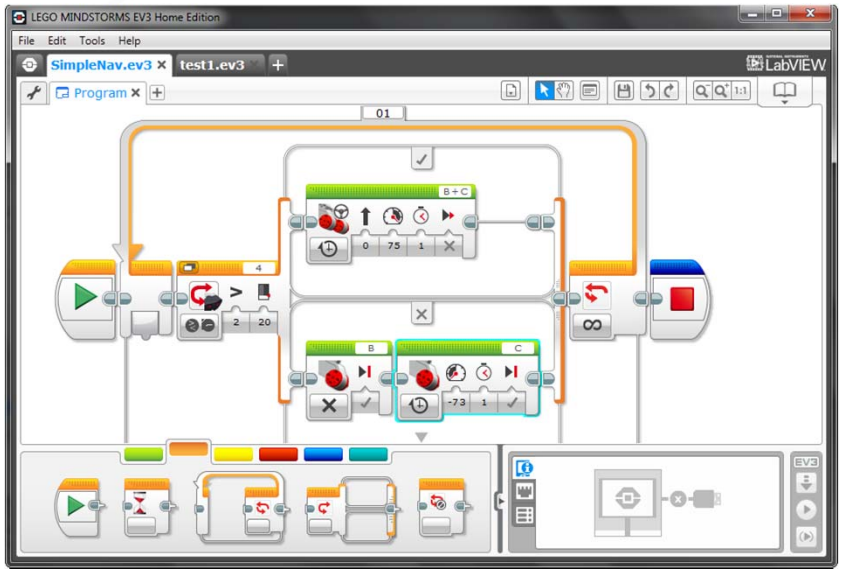
Direct Teach

Baxter, Rethink Robotics

- No pendant
- Requires extra thought be given to worker/programmer safety.
- Flexible to program, but limited at playback

How are robots programmed?

Software Development Kit (SDK)



Lego Mindstorms Software Development Kit (SDK)

- Relatively simple way to develop complex programs
- Often includes *Integrated Development Environment* (IDE)
- May be graphical
- Fully programmable within scope of SDK/IDE

How are robots programmed?

Computer Programming

```cpp
#include <ros/ros.h>
#include <moveit/move_group_interface/move_group.h>
#include <geometric_shapes/shape_operations.h>
#include <moveit/robot_state/conversions.h>
#include <workcell_interface/workcell_interface.h>
#include <std_msgs/Int8.h>
#include <assembly/tool_status.h>

std::map<std::string, moveit_msgs::Grasp> grasp_map;
std::map<std::string, geometry_msgs::Pose> tool_storage;
assembly::tool_status tool_state;
bool assembly_init();

int main(int argc, char** argv)
{
  if(argc < 2)
  {
    std::cout << "Too few arguments to assembly_main. Usage: assembly_main [bool, use_gripper_interface]" << std::endl;
    return false;
  }

  ros::init(argc, argv, "assembly_main");
  ros::NodeHandle n;

  ros::Publisher status_pub = n.advertise<std_msgs::Int8>("assembly_status", 10);
  std_msgs::Int8 status;
  std_msgs::Bool stop;
  stop.data = true;
  status.data = 0;
  status_pub.publish(status);

  ros::AsyncSpinner spinner(1);
  spinner.start();

  //Set up workcell interface
  WorkcellInterface workcell("pia10");
  workcell.Init(n, atoi(argv[1]), "set_changer", "set_gripper");

  ros::Subscriber cancel_sub = n.subscribe("assembly/safe_stop", 1, &WorkcellInterface::SafeStop, &workcell);

  //Call init function to get application stuff set up.
  assembly_init();

  //Get the tool.
  if(!workcell.tool_equipped){
    if(!workcell.EquipTool("gripper", grasp_map["gripper"]))
    {
      ROS_INFO("Unable to perform pick maneuver.");
      status.data = -1;
      status_pub.publish(status);
      workcell.SafeStop(stop);
      workcell.GenerateReport("tool_equip");
      return 0;
    }
  }
  ros::Duration(0.5).sleep();

  //Get the hemishell.
  if(!workcell.Pick("hemishell", grasp_map["hemishell"]))
  {
    ROS_INFO("Unable to perform pick maneuver.");
    status.data = -1;
    status_pub.publish(status);
    workcell.SafeStop(stop);
    workcell.GenerateReport("hemi_pick");
    return 0;
```

Snippet of C++ code

- Requires ability to write *code*
- Application Programming Interface (API)
- Many languages available (C++, Java, C#, Python)
- Fully programmable and *extensible*

Discussion

- Questions:
  - When would you use each programming method?
  - Who would be likely to use each programming method?
  - What are the *trade-offs* between different programming methods?
- Thoughts:
  - Robustness vs Flexibility
  - Operators, programmers, researchers

So how do you become a roboticist?

- A roboticist works in robotics, but what is robotics?
  - Mechanical Engineering
  - Electrical Engineering
  - Computer Science
  - Psychology
  - Sociology
  - Law
  - Economics

So you want to work with robots?

- What skills do you need?
  - Mathematics
  - *Broad* science and engineering
  - Specialization in some aspect of robotics
- What else?
  - Creativity – There are many ways to skin a robot.
  - Perseverance – Code **never** works the first time.
  - Love of learning – It doesn't stop after school.